

99/01517 Modular approach to analysis of chemically recuperated gas turbine cycles

Carcasci, C. *et al.* *Energy Convers. Manage.*, 1998, 39, (16–18), 1693–1703. Compared to industrial gas turbines, aeroderivatives offer high simple cycle efficiency and the capability to start quickly and frequently without a significant maintenance cost penalty. A key element for high system performance is the development of improved heat recovery systems, leading to advanced cycles such as the humid air turbine (HAT) cycle, the chemically recuperated gas turbine (CRGT) cycle and the Kalina combined cycle. When used in combination with advanced technologies and components, it has been predicted that such advanced cycles could theoretically lead to net cycle efficiencies exceeding 60%. In this paper, the authors present the application of the modular approach to cycle simulation and performance predictions of CRGT cycles. The modular simulation code concept and the main characteristics of CRGT cycles are introduced. Furthermore, the paper discusses the development of the methane-steam reformer unit model used for the simulations. The modular code is then used to compute performance characteristics of a simple CRGT cycle and a reheat CRGT cycle, both based on the General Electric LM6000 aeroderivative gas turbine.

99/01518 Multi-step constant-current charging method for electric vehicle, valve-regulated, lead/acid batteries during night time for load-levelling

Ikeya, T. *et al.* *Journal of Power Sources*, 1998, 75, (1), 101–107. If electric vehicles (EVs) are to be popularized, the conditions for charging EV batteries with available current patterns should allow complete charging in a short time, i.e. less than 5 to 8 h. Therefore, in this study, a new charging condition is investigated for the EV valve-regulated lead/acid battery system, which should allow complete charging of EV battery systems with multi-step constant currents in a much shorter time with longer cycle life and higher energy efficiency compared with two-step constant-current charging. Although a high magnitude of the first current in the two-step constant-current method prolongs cycle life by suppressing the softening of positive active material, too large a charging current magnitude degrades cells due to excess internal evolution of heat. A charging current magnitude of approximately 0.5 C is expected to prolong cycle life further. Three-step charging could also increase the magnitude of charging current in the first step without shortening cycle life. Four- or six-step constant-current methods could shorten the charging time to less than 5 h, as well as yield higher energy efficiency and enhanced cycle life of over 400 cycles compared with two-step charging with the first step current of 0.5 C. An investigation of the degradation mechanism of the batteries revealed that the conditions of multi-step constant-current charging suppressed softening of positive active material and sulfation of negative active material, but, unfortunately, advanced the corrosion of the grids in the positive plates. By adopting improved grids and cooling of the battery system, the cycle life may be enhanced by the multistep constant-current method.

99/01519 Performance of a mixed gas-steam cycle power plant obtained upgrading an aero-derivative gas turbine

Camporeale, S. M. and Fortunato, B. *Energy Convers. Manage.*, 1998, 39, (16–18), 1683–1692.

This paper analyses the performance that can be achieved in a power plant by upgrading a typical aero-derivative gas turbine. The methodology is based on the analysis of the gas generator (compressor and high pressure turbine) in the upgraded plant configuration and is applied to the design of a power plant based on the recuperative water injected cycle. The operating region and boundary of the gas generator were evaluated for the upgraded plant configuration and an optimization procedure was established in order to show the maximum efficiency and power output that can be achieved.

99/01520 Reduction in CO₂ emission by biomass power generation with sustainable afforestation. Evaluation by LCA (Life Cycle Assessment)

Tahara, K. *et al.* *Nippon Enerugi Gakkaishi*, 1998, 77, (5), 403–409. (In Japanese)

Evaluated by LCA (Life Cycle Assessment) methodology, was CO₂ emission from biomass power generation system with sustainable afforestation. Calculation was conducted for typical case (15 km × 15 km). CO₂ emission from sustainable afforestation system was calculated to be 2.1×10^7 kg-CO₂/yr. That from construction of biomass power plants was calculated to be 5.0×10^5 kg-CO₂/yr. CO₂ emission from power plant construction was negligibly small. Net CO₂ reduction effect of replacing coal by biomass was calculated to be 2.4×10^8 kg-CO₂/yr. By the replacement, it was suggested that the biomass power generation system possibly reduces large quantity of CO₂ emission. CO₂ emission from afforestation was about 8% of the CO₂ reduction effect. Calculated to be at about 0.2 years, the energy pay back time of the biomass power generation system with sustainable afforestation has been estimated.

99/01521 A study on LBG-fuelled 1500°C-class gas turbine combustor for use in IGCC (2nd report, combustion characteristics under high pressurized conditions)

Hasegawa, T. *et al.* *Nippon Kikai Gakkai Ronbunshu, B-hen*, 1998, 64, (621), 1524–1530. (In Japanese)

In the integrated coal gasification combined cycle (IGCC) system the development of a high temperature, gas turbine combustor using coal-derived, low-Btu gaseous (LBG) fuel which has high thermal efficiency and

low NO_x emission is required. The authors of this paper have developed a 150 MW, 1500°C-class gas turbine combustor which adopts an advanced two-staged combustion technology designed mainly for achieving low NO_x emissions and stable combustion. Under high-pressurized conditions, NO_x emissions have been successfully reduced when fuel contains ammonia of 1000 ppm and flame stability has been maintained. Moreover, many design guidelines have been optimized by clarifying the effect of pressure on combustion characteristics. This paper describes in detail the effects of pressure in IGCC on the characteristics of the advanced, two-staged combustion technology for use in a gas turbine combustor.

99/01522 Theoretical limits on the performance of Stirling engines

Senft, J. R. *Int. J. Energy Res.*, 1998, 22, (11), 991–1000.

Presented in this paper is a mathematical model of engines operating with an ideal Stirling cycle and subject to limited heat transfer, internal thermal losses and mechanical friction losses. The goal of the paper is to describe the fundamental effects of these imperfections on the performance of an otherwise ideal Stirling engine. These are defects suffered by all real Stirling engines, but the intent here is not to predict the actual performance of specific engines. Rather, the aim is to obtain some mathematical insight into the nature of the theoretical dependence of engine performance upon these imperfections.

99/01523 Thermodynamic analysis of injected water recovery systems for the humid air turbine (HAT) cycle

Bidini, G. *et al.* *AES (Am. Soc. Mech. Eng.)*, 1996, 36, 295–303.

The humid air turbine (HAT) cycle is an inter-cooled gas turbine cycle. It has an air-water mixing evaporator before the combustion chamber and a heat recovering system for the exhaust gases. The considerable amount of water consumed in the mixing evaporator (about 1200–2400 m³ daily for a 100 MW unit) represents a significant drawback to the use of the HAT cycle as well as of other steam injected gas turbines. In fact, this means high operational costs for water treatment and eventual legislative restrictions limiting the use of water, not to mention the environmental impact of the depletion of water resources. The aim of this paper is to evaluate the changes in the performance of the HAT cycle when a water recovery system is added in the exhaust gases and to determine the heat exchangers conditions for maximum water and heat recovery. Finally, the size of a surface condenser for water recovery is determined for a given HAT cycle power output. The results show the possibility to recover up to 85% of the consumed water and up to 30% of input heat from the condensation of the water contained in the exhaust gas. The paper also examines all the thermodynamic processes in each cycle component from the viewpoint of recovering water from the exhaust gas. The relative amounts of water and their contributions to the overall heat recovery are also calculated since part of the water contained in the exhaust gas is due to the inlet air humidity and the combustion process.

99/01524 The use of computer simulation in the evaluation of electric vehicle batteries

Gu, W. B. *et al.* *Journal of Power Sources*, 1998, 75, (1), 151–161.

In order to evaluate batteries for electric vehicle (EV) applications, an integrated simulation and testing approach is presented. This new approach combines traditional experimental testing with computer simulations to create a cost-effective means to evaluate EV batteries and provide important information that is difficult or impossible to obtain from purely experimental measurements. The present simulators for the lead-acid and nickel-metal hydride (Ni-MH) batteries are developed based on the fundamental principles governing their electrochemical behaviours and are created using an advanced computational fluid dynamics (CFD) technique. Computer simulations are validated by experimental data under the dynamic stress test (DST) procedure for a lead-acid battery module and a Ni-MH cell. Moreover, computer simulations reveal that the studied lead-acid battery underutilizes the active material by as much as 70% and the MH electrode of the Ni-MH cell is overdesigned by about 30% under the simulated EV duty. Therefore, if batteries are optimized for EVs using a simulation-based design approach, there is good potential of increasing the specific energy and reducing the cost.